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# Improved electrodes and gas impurity investigations on alkaline electrolyzers

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## Motivation

Alkaline water electrolysis for hydrogen production is a well-established technique but some technological issues regarding the coupling of alkaline water electrolysis and Renewable Energy Sources (RES) remain to be improved.

Targets:

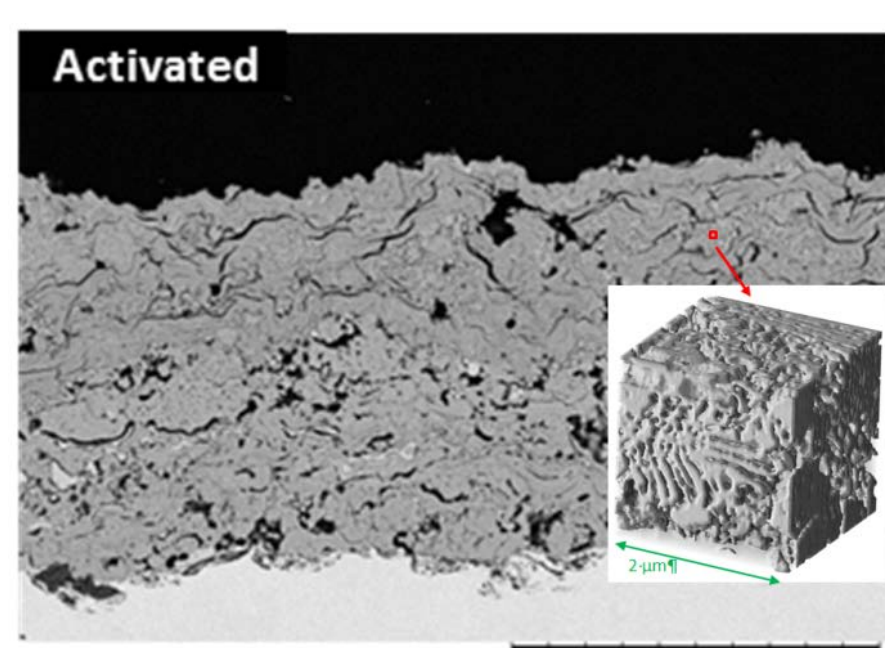
- fluctuating power operation
- decrease of system costs
- higher operating pressure
- high efficiency, high current density
- ability to tolerate periods of non-operation

by

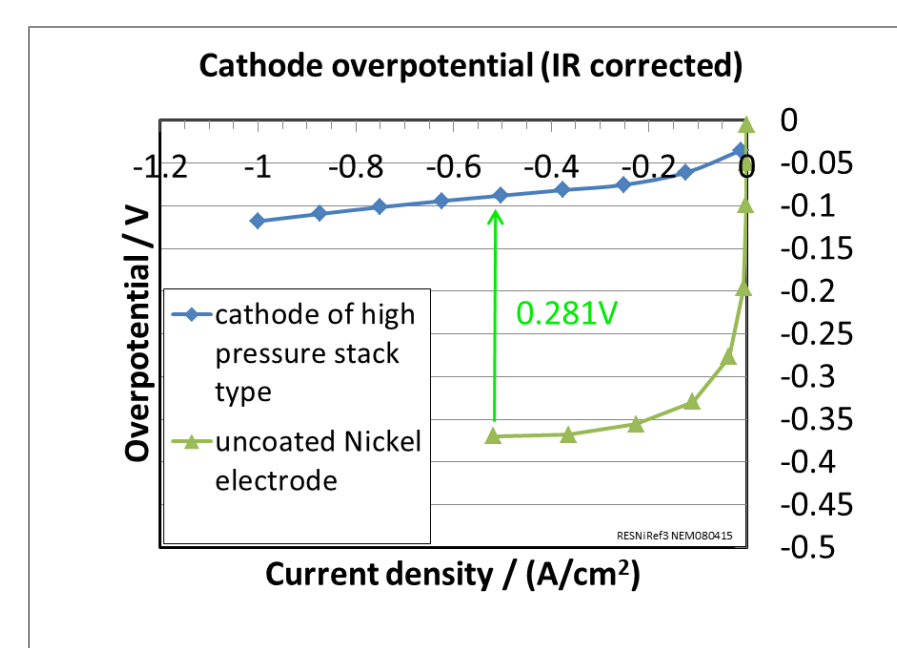
- electrodes with low cost coatings
- improved gas purity at low current density with new separator design

## Methods and Results

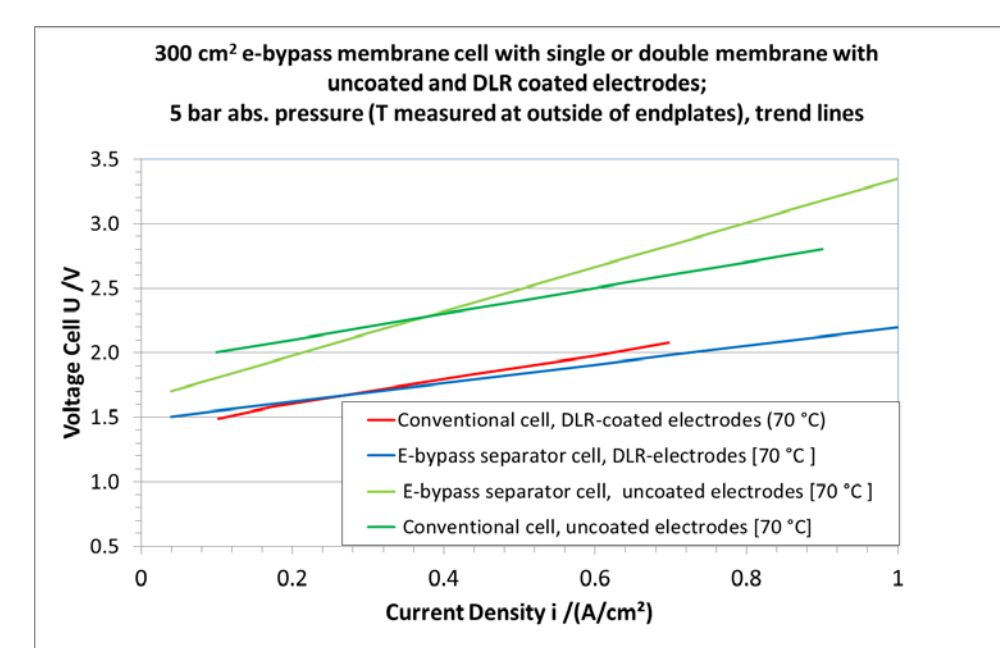
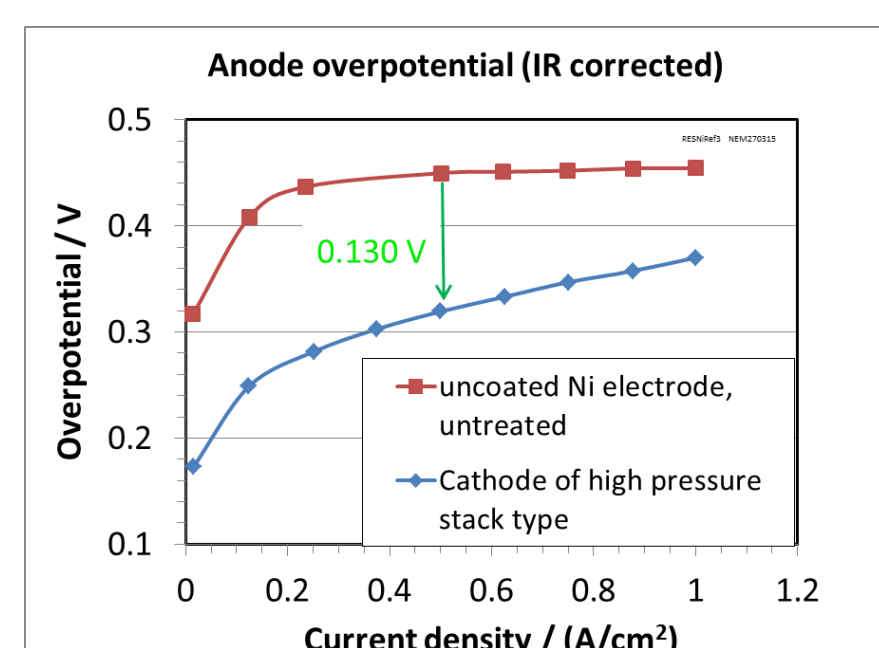
### Electrodes



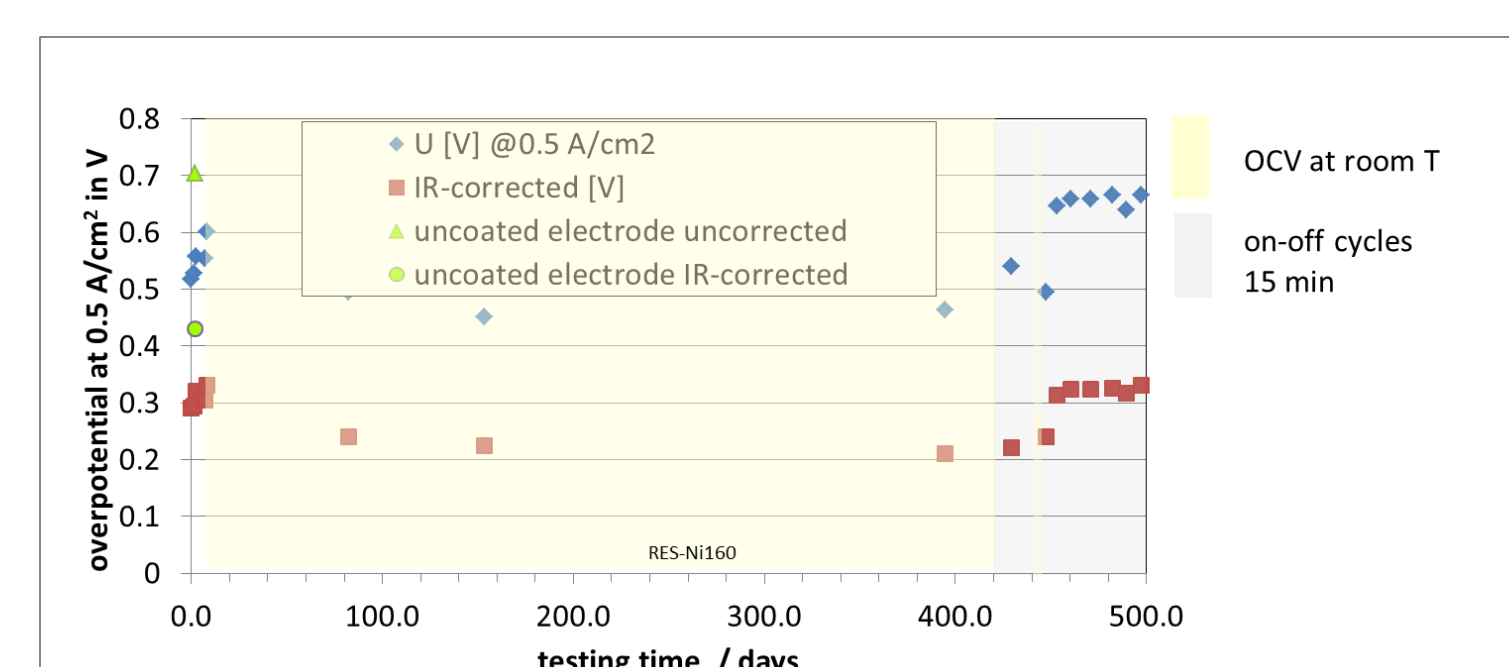
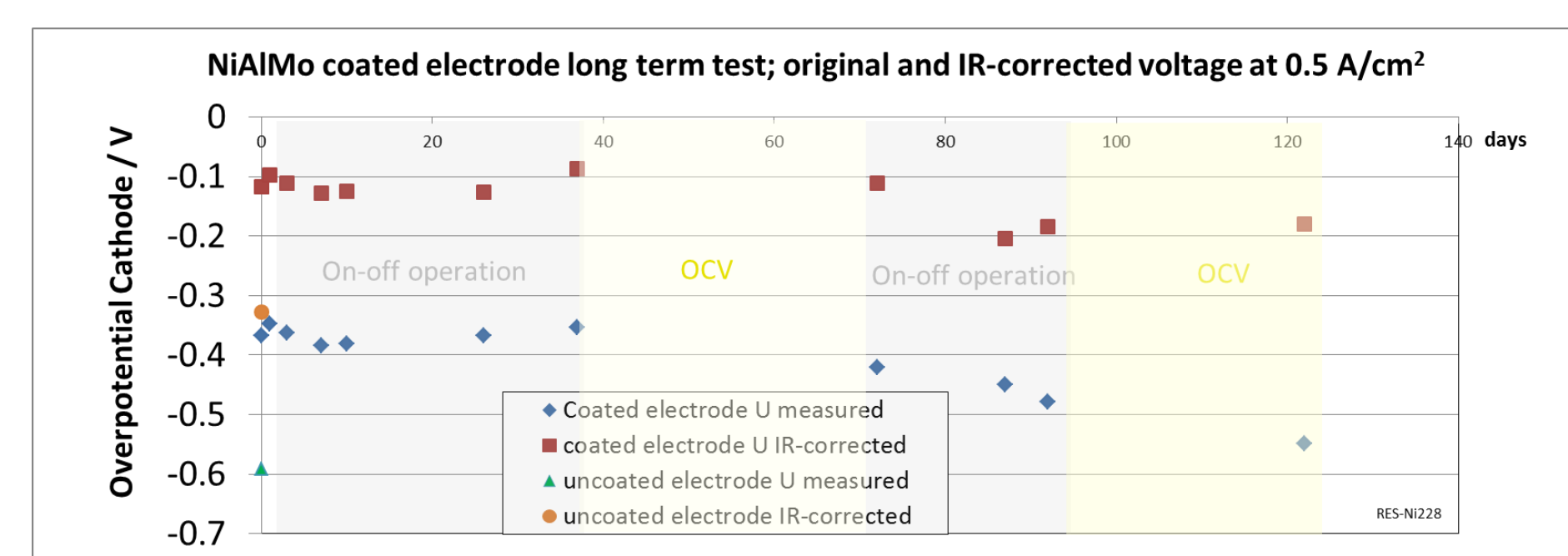
Cross-sectional SEM images of vacuum plasma sprayed Raney Ni hydrogen electrodes in the activated state. The cathode consists of two layers on the Ni substrate: the outer Al-Ni-Mo active surface layer and the inner Al-Ni bonding layer. Inset: Three dimensional reconstruction of a tested cathode by focused ion beam tomography revealing internal porosity. DTU



Comparison of coated and uncoated nickel expanded metal sheet electrodes. Half cell measurement of 4 cm² electrodes coated with NiAlMo and NiAl intermediate layer for the cathode (left) and NiAl for the anode (right), 70 °C, 30 wt.% KOH



Electrodes were plasma-spray coated with low cost Ni alloy coatings (AlNi and AlNiMo). After activation (Raney-Nickel) high porosity is achieved and electrodes show overpotential reduction in half cell and full cell tests. Long-term stability in on-off operation is demonstrated in half cell measurements. Further improvement of efficiency in full cell operation is expected after upcoming experiments with new current density distribution measurement.

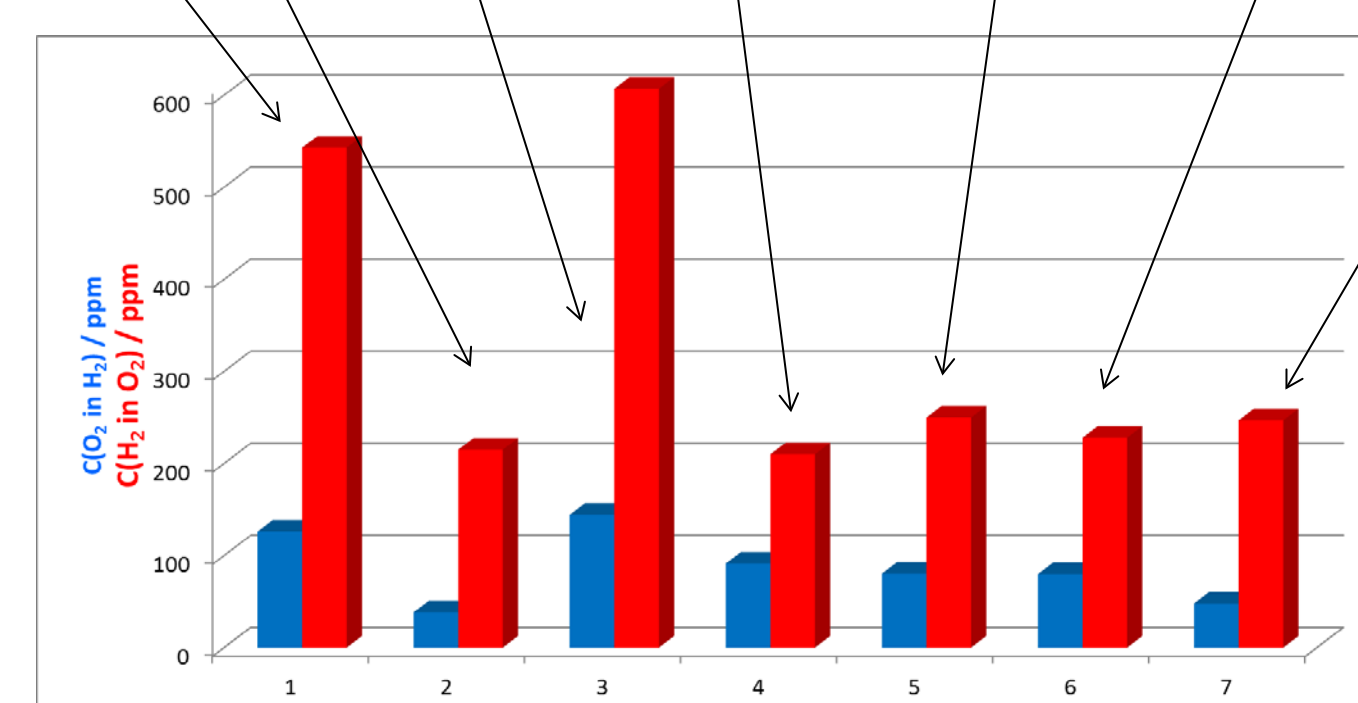
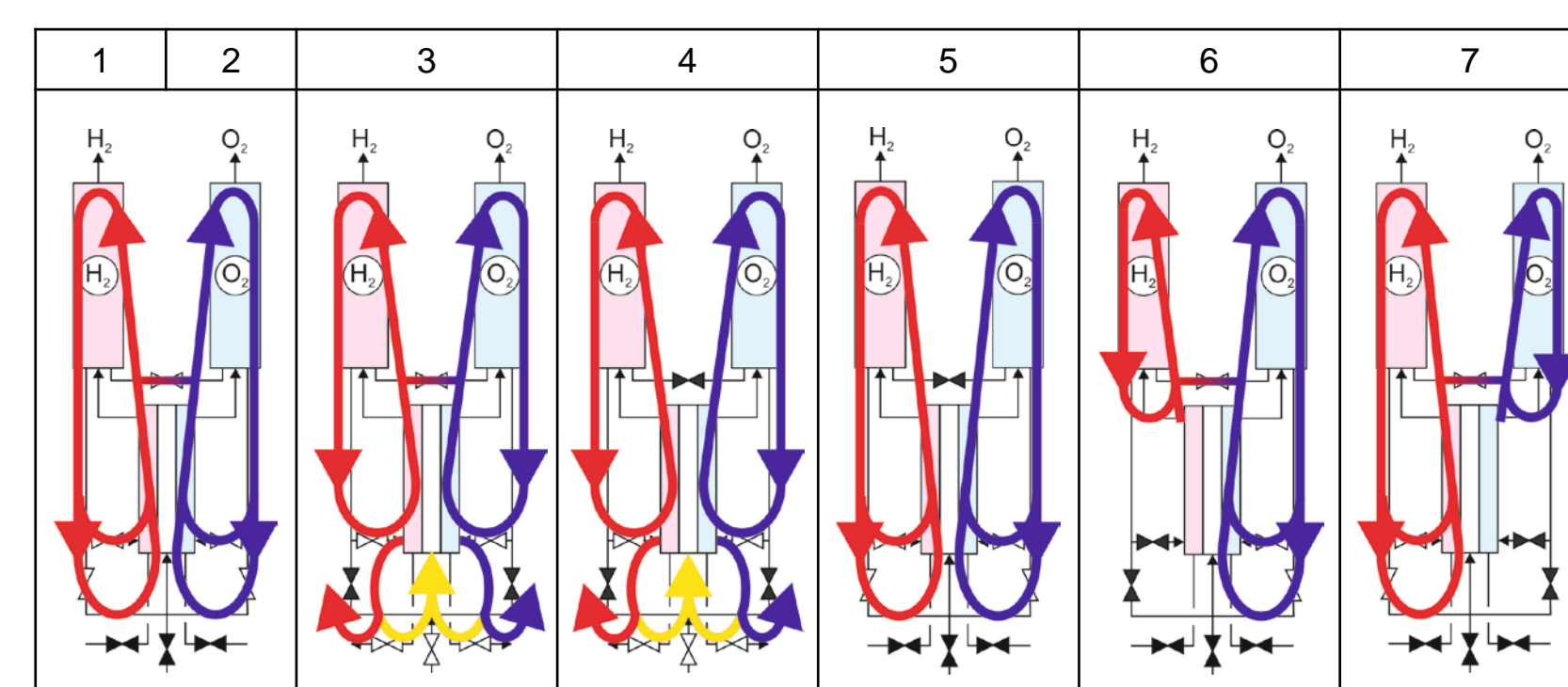
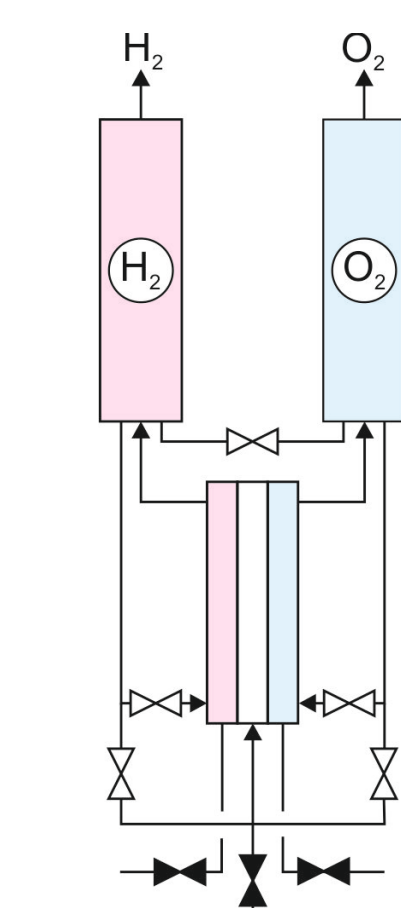
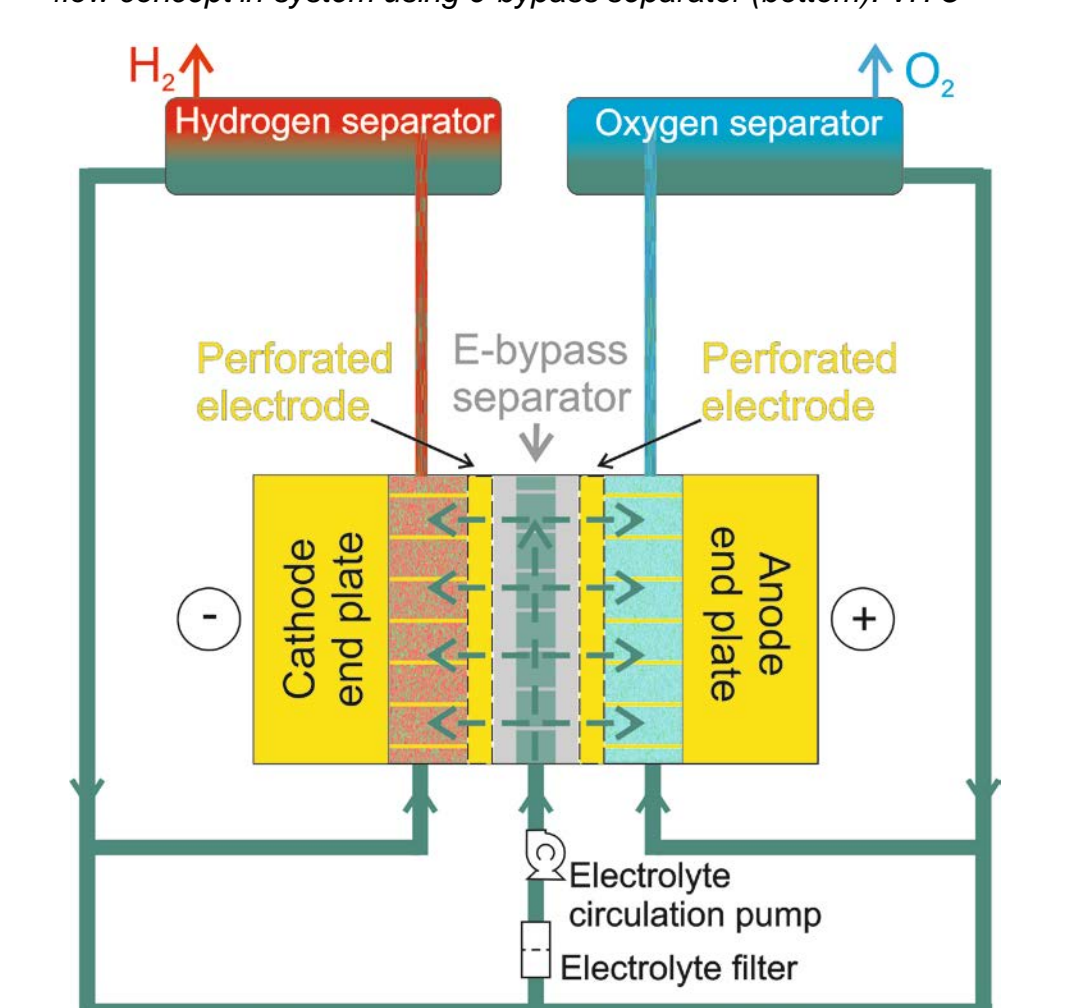


Long-term test of anode and cathode coated by VPS in intermittent operation, 0.5 A/cm², 70 °C. Left cathode total time: 2930 h, 2780 on-off cycles (each 15 min).; Right: Operation time anode: 11.937 h (497 days), 3204 on-off cycles.

### Gas Impurity



E-bypass separator (top); inset: SEM image of cross section (top); KOH flow concept in system using e-bypass separator (bottom). VITO



Flow configurations and measured gas impurities. Cell-Temperature: 70 °C, KOH-Flowrate: 15 ml/min, KOH-Temperature (Tank): 40 °C, Current: 45 A (150 mA/cm²), cell with e-bypass separator and DLR coated electrodes. Top left: the system with valves; top: flow configuration number 1-7, bottom: measured gas impurities for flow configuration 1-7.

Using a new cell concept with double layer separator (e-bypass separator) different flow concepts were tested. The primary purpose of this concept is to reduce the amount of H<sub>2</sub> impurities in O<sub>2</sub> and O<sub>2</sub> impurities in H<sub>2</sub> and at low current density due to diffusion of gases dissolved in KOH. It was found that there are further influences on gas quality by:

- single/double layer separator; permeability
  - flows of KOH in cell e.g. due to differential pressure
  - electrodes quality
  - flows of KOH with microbubbles between gas separators → quality of gas separators
- further measurements and simulations necessary to understand and improve gas quality even with single separator

Lowest gas impurities achieved at 0.150 A/cm², 70 °C	O <sub>2</sub> in H <sub>2</sub> / ppm	H <sub>2</sub> in O <sub>2</sub> / ppm
With single separator, coated electrodes	77	980
With e-bypass separator, coated electrodes, first cell	63	250
With e-bypass separator, coated electrodes, last cell	38	215

## Summary and Conclusions

- Electrodes with Raney-nickel-alloy coatings (low cost material) → overpotential reduction of 330 mV
- Electrodes show excellent stability: 1100 on-off cycles, 98% of initial efficiency retained
- Hydrogen in oxygen impurity reduced by ≥ factor of 4 due to e-bypass-separator (double layer separator)
- Cell can be operated at higher pressure and/or lower current density before reaching the limiting gas concentration
- Gas impurity in an electrolyzer depends on many more factors than only which type of separator is used
- For further improvement of electrolyzers study of internal problems using current density distribution measurements has been started

## References

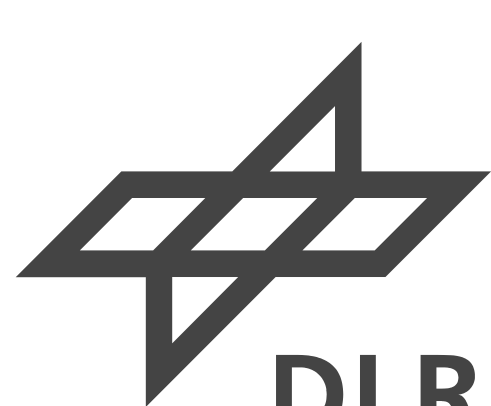
Further information:  
Project RESelyser  
[www.reselyser.eu](http://www.reselyser.eu)

Final report RESelyser  
[www.reselyser.eu/14.html](http://www.reselyser.eu/14.html)

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